Quantification of carbon accumulation in eleven New England eelgrass meadows

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Eelgrass (*Zostera marina*)

- Cool water species (<25°C) found in shallow (0-10 m) waters
- Prefers wave-sheltered areas with soft sediments
- Needs high water clarity/high light
- Known to provide habitat for fish and shellfish
- Provides protection from waves and storm surge
- Improves water quality and stabilizes sediments
- Meadows known to sequester carbon

High seagrass area suggests high potential for carbon burial

Table 1. Carbon burial and global area of vegetated coastal ecosystems

Ecosystem	Carbon burial rate ($g\ C\ m^{-2}\ yr^{-1}$) mean ± SE	Global area (km^2)	Global carbon burial* ($Tg\ C\ yr^{-1}$) mean ± SE	Sources: Global area	Sources: Carbon burial
Salt marshes	218 ± 24 (range = 18–1713) *n* = 96 sites	22 000**– 400 000	4.8 ± 0.5 87.2 ± 9.6	Chmura *et al.* (2003); Duarte *et al.* (2005a)	Chmura *et al.* (2003); Duarte *et al.* (2005a)
Mangroves	226 ± 39 (range = 20–949) *n* = 34 sites	137 760 – 152 361	31.1 ± 5.4 34.4 ± 5.9	Giri *et al.* (2010); Spalding *et al.* (2010)	Chmura *et al.* (2003); Bird *et al.* (2004); Lovelock *et al.* (2010); Sanders *et al.* (2010)
Seagrasses	138 ± 38 (range = 45–190) *n* = 123 sites	177 000 – 600 000	48–112	Charpy-Roubaud and Sournia (1990); Green and Short (2003); Duarte *et al.* (2005b)	Duarte *et al.* (2005a); Duarte *et al.* (2010); Kennedy *et al.* (2010); Duarte (unpublished data)

Notes: *We calculated global carbon burial values using the mean carbon burial rate and the minimum and maximum global area values for salt marshes and mangroves. Global carbon burial values for seagrasses are from Kennedy *et al.* (2010). **No global inventory of salt marshes has been published, so Chmura *et al.* (2003) estimated 22 000 km^2 of salt marshes based on inventories for Canada, Europe, the US, and South Africa. SE = standard error.

Mcleod et al. 2011

Why was this study conducted?

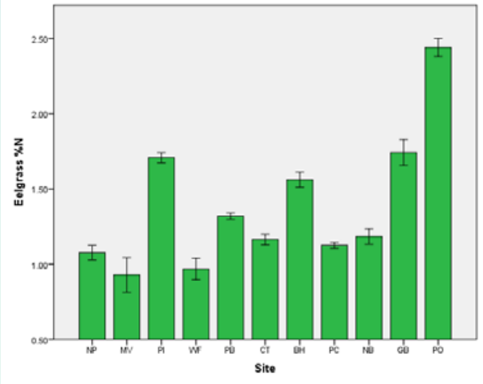
- Seagrass meadows not as well characterized as intertidal habitats
- Dearth of published carbon sequestration data north of Chesapeake Bay
- High variability in the carbon sequestration data, suggesting that not all meadows accumulate equal amounts of carbon
- Important to understand the factors that control the rates and fates of carbon accumulating in these systems
- Allow prioritization of sites for conservation or mitigation efforts

Fourqurean et al. 2012

Study Sites

- Eleven sites with established eelgrass beds
  - Portland (PO)
  - Great Bay (GB)
  - Gloucester (NB)
  - Nahant (PC)
  - Boston Harbor (BH)
  - Cohasset (CT)
  - Orleans (PB)
  - West Falmouth (WF)
  - Prudence (PI)
  - Marthas Vineyard (MV)
  - Ninigret (NP)

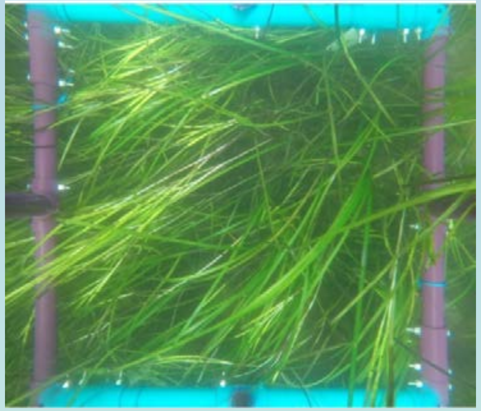
- Sites with a range of N input and wave exposure



Field Sampling

- Sediment traps
  - 2 week deployment
  - Eelgrass and reference areas

- Vegetation
  - Bed structure (shoot density) - 5 random quadrats (0.0625 m^2)
  - 20 random shoots for morphology/tissue analysis
  - Leaf marking – 2 weeks to allow growth



- Sediment cores
  - Eelgrass and reference areas (30 cm deep, 0.067 m diameter cores)
  - Grain size and bulk density (1 core/area)
  - Carbon and nitrogen content and stable isotopes (3 cores/area)
  - ^{210}Pb (1 core/eelgrass area)

Sample Analysis

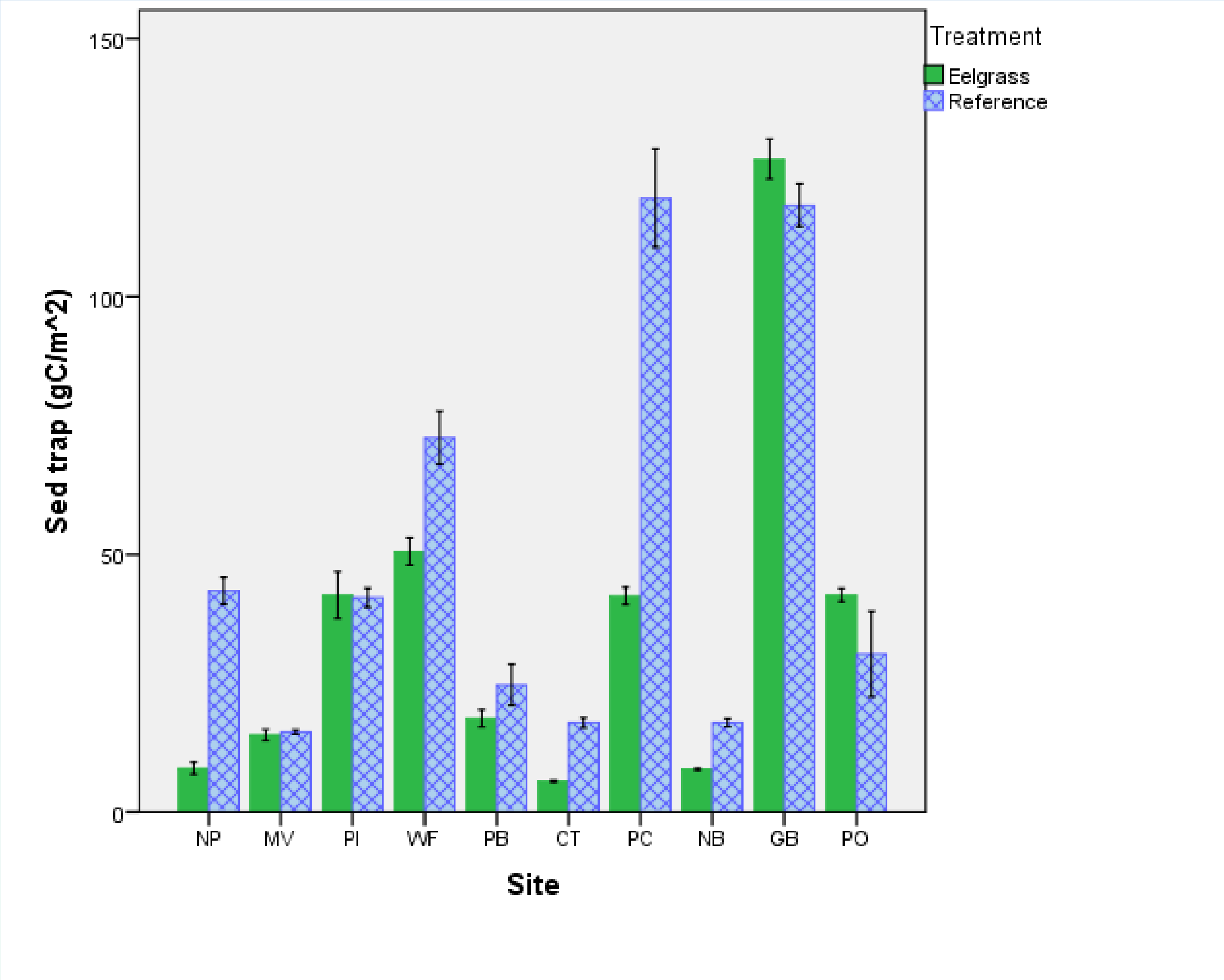
- Sediment trap
  - Volume of material
  - IRMS analysis (%C, %N, $\delta^{13}C$, $\delta^{15}N$)

- Sediment core
  - Bulk C
  - Grain size distribution
  - IRMS analysis (%C, %N, $\delta^{13}C$, $\delta^{15}N$)

- Vegetation
  - Plant morphology
  - Above and belowground biomass
  - IRMS analysis (%C, %N, $\delta^{13}C$, $\delta^{15}N$)

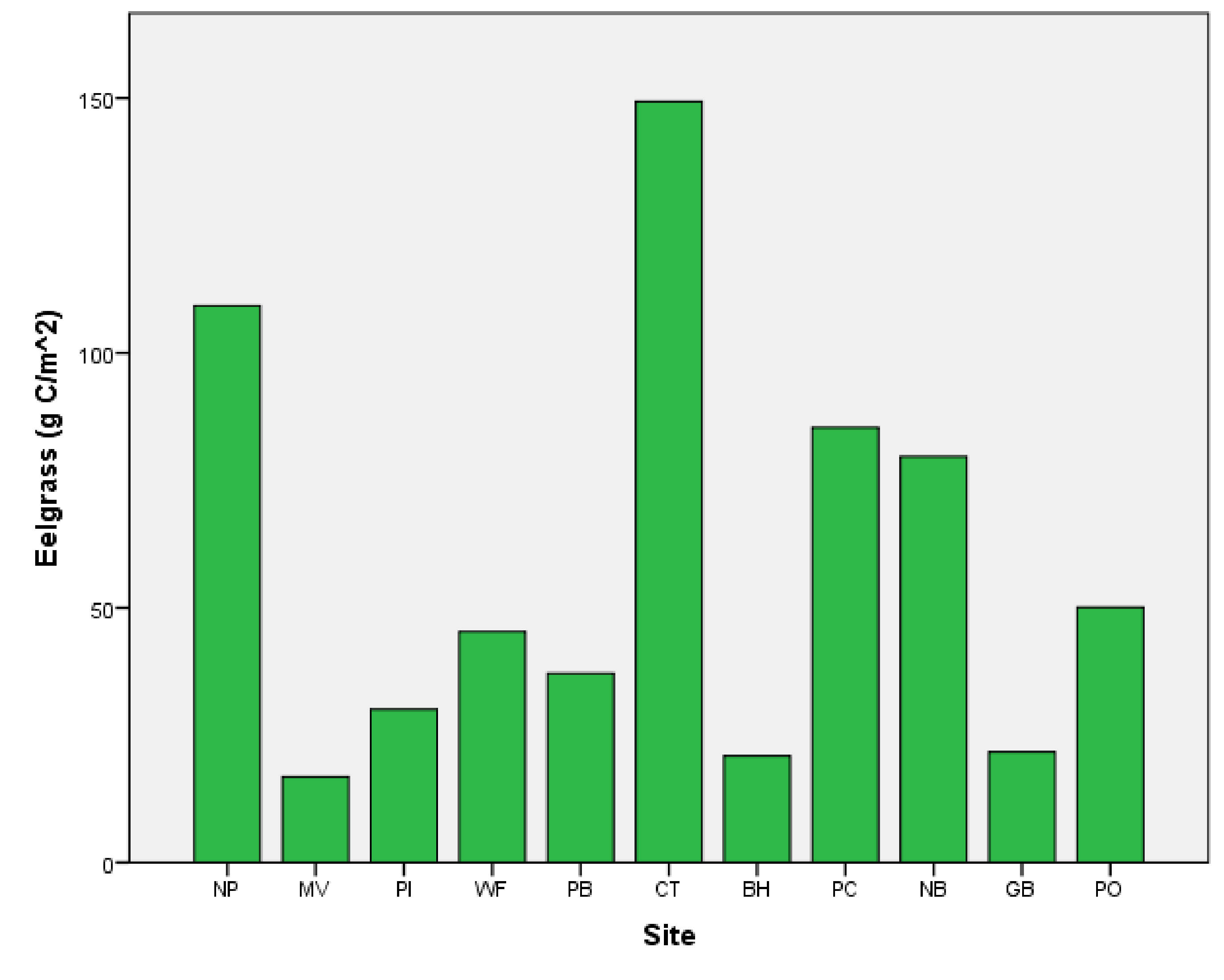
Results

Sediment Trap Data



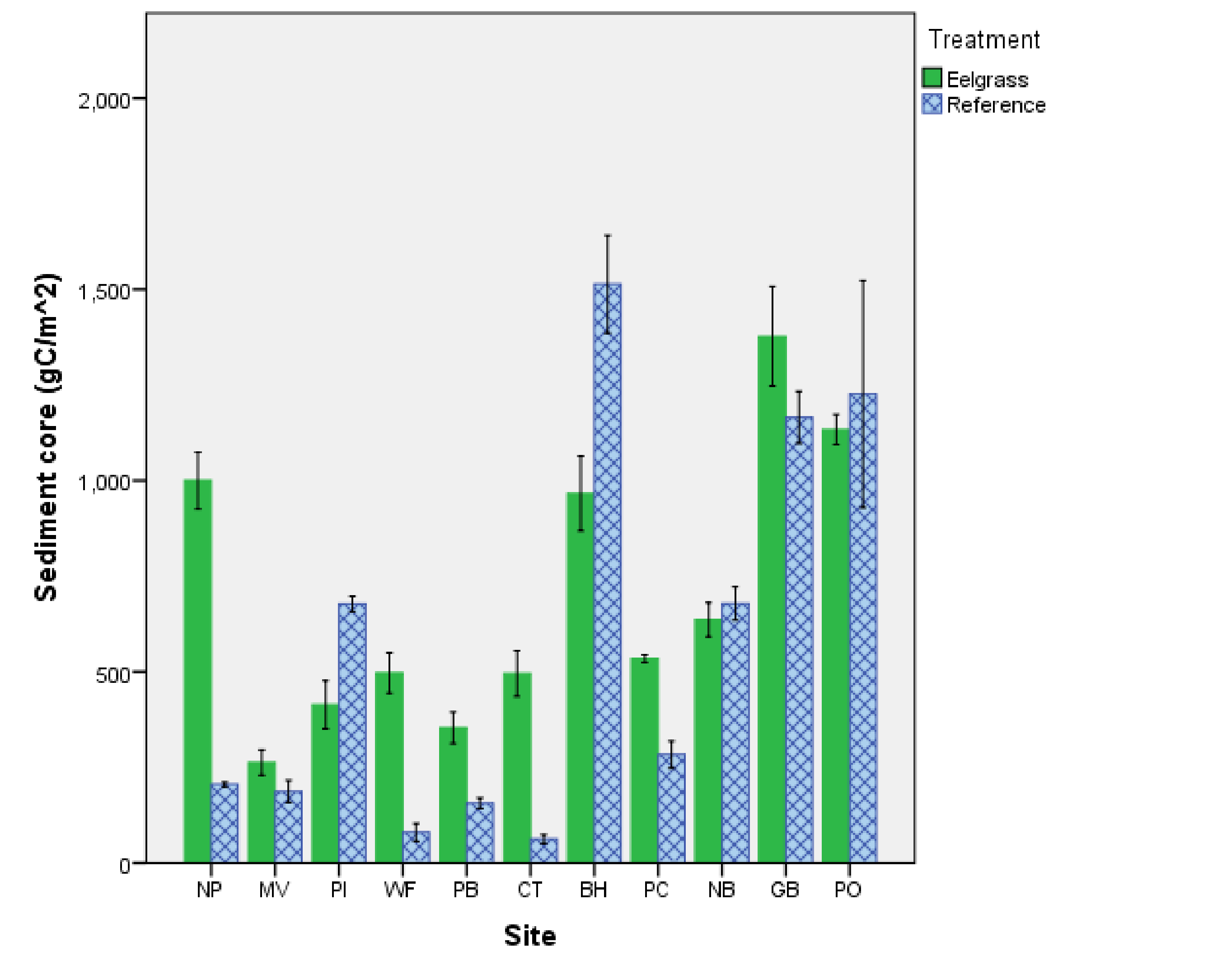
- Significant differences among sites
- No significant difference between eelgrass and reference areas, but a significant site x treatment effect
- Generally higher amounts of carbon in higher latitude sites

Seagrass Data



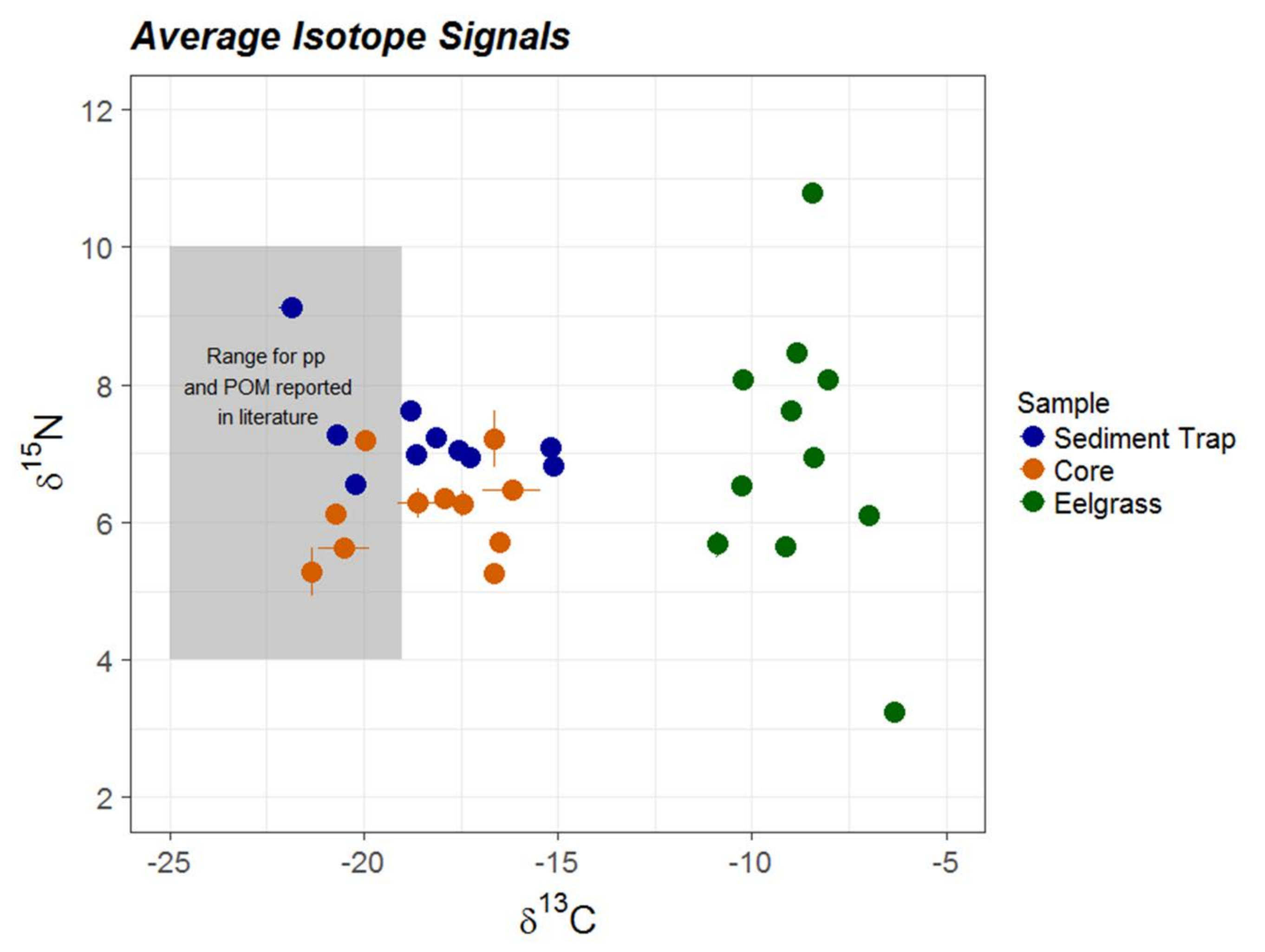
- Although there were evident differences among sites, this difference was not related to latitude

Sediment Core Data



- There were significant differences among sites
- There was no difference between reference and eelgrass areas.
- However, there was a significant site x treatment effect
- For most sites (7/11), sediment carbon was higher within seagrass beds than in reference areas

What is the source of the sediment carbon?



Expected pp/POM range from Fry & Wainbright, 1991, Oczkowski et al. 2014

- Vegetation isotopic values were distinct from the core values
- Sediment trap material was more similar to core isotopic values, although the cores were generally slightly depleted in $\delta^{15}N$
- Stable isotope results suggest that sediment carbon is a combination of plant tissue and phytoplankton/POM

How old are our cores?

Site		Sediment Accumulation rate ($g/cm^2/yr$)	Carbon Accumulation rate ($g/m^2/yr$)	Core age (yr)
Portland	(PO)	*In Progress*	*In Progress*	*In Progress*
Great Bay	(GB)	1.17 ± 0.13	225 ± 25	20
Gloucester	(NB)	0.12 ± 0.07	19.2 ± 9.8	100+
Nahant	(PC)	0.26 ± 0.05	17.9 ± 3.3	75
Boston Harbor	(BH)	*In Progress*	*In Progress*	*In Progress*
Cohasset	(CT)	0.17 ± 0.02	6.9 ± 0.7	94
Orleans	(PB)	0.39 ± 0.02	11.3 ± 0.5	65
West Falmouth	(WF)	*No Data*	*No Data*	*No Data*
Prudence Island	(PI)	*In Progress*	*In Progress*	*In Progress*
Martha's Vineyard	(MV)	*No Data*	*No Data*	*No Data*
Ninigret	(NP)	0.35 ± 0.02	123 ± 5	39

How does our study compare with other studies?

	Seagrass aboveground C ($g\ C/m^2$)			Sediment C ($g\ C/m^2$)		
Global Average*	251	±	49	19420	±	202
North Atlantic*	85	±	19	4870	±	1450
This study	17	-	149	163	-	1377

* Fourqurean et al. 2012

Conclusions

- Carbon accumulation was generally higher in eelgrass beds than in nearby reference sites
- New England seagrass meadows accumulate variable but potentially large amounts of carbon
- Sequestered carbon was only slightly lower than published summaries of C accumulation in North Atlantic eelgrass beds
- Substantial amounts of carbon stored in eelgrass meadows appears to originate form outside the meadow
- In many meadows, carbon has been stored for decades or near a century

Next

My colleague Alyssa Novak will be talking about the factors that influence carbon sequestration in our New England seagrass meadows

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